TECHNICAL REPORT RD-SS-01-28

RDEC FEDERATION IMPLEMENTATION OF OBJECTIVE FORCE BATTLESPACE (OFB) ARCHITECTURE

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September 2001

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 2001	Final

4. TITLE AND SUBTITLE
RDEC Federation Implementation of Objective Force Battlespace (OFB) Architecture

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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Redstone Arsenal, AL 35898-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
TR-RD-SS-01-28

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; Distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 Words)*
The Army Materiel Command (AMC) Research, Development, and Engineering Center (RDEC) Federation, combined with the Joint Virtual Battlespace (JVB) and Mounted Maneuver Battle Lab (MMBL) simulation architectures, comprises the real-time simulation architecture central to the Objective Force Battlespace (OFB) framework. This document describes the RDEC Federation architectural approach, interfaces, synthetic natural environment, and key architecture components, as they relate to OFB experimentation and analysis.

14. SUBJECT TERMS
Research, Development, and Engineering Center (RDEC), Objective Force Battlespace (OFB), High Level Architecture (HLA)

15. NUMBER OF PAGES
16

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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I. INTRODUCTION

The Army Materiel Command (AMC) Research, Development, and Engineering Center (RDEC) Federation is a distributed engineering and engagement level modeling and simulation environment, with capability to extend and interoperate with battle and campaign level models and simulations. It supports Research, Development, and Acquisition (RDA) mission equipment simulation and evaluation, as well as supporting the Army in executing tasks in the Advanced Concept Requirements (ACR) and Training Exercise Military Operation (TEMO) domains as envisioned in the Army's Simulation and Modeling for Acquisition, Requirements, and Training (SMART) initiative. The key objectives are to support the Chief of Staff's initiatives in fielding a fully integrated digitized battlefield, Medium Brigade, and the Army Transformation effort towards the Objective Force (OF) by reducing systems acquisition time, reducing rework, improving configuration management, and providing the soldier in the field safer, more reliable and effective products.

The AMC RDEC Federation is a persistent High Level Architecture (HLA) based collaboration of United States (U. S.) Army RDECs, Army Research Laboratory (ARL), and Simulation, Training, and Instrumentation Command (STRICOM), which evolves as simulation capabilities at each RDEC change, with collections of federates participating in individual events based upon customer needs and technical objectives. The usable product of this effort is a distributed, collaborative, composable modeling and simulation environment with robust Models and Simulation (M&S) capabilities and architecture sufficient to support analysis of the OF. The initial objective of the RDEC Federation is to develop an HLA compliant testbed to support Future Combat System (FCS) analysis and experimentation. Key efforts include the linking of each RDEC/Laboratory's high-resolution models so that an integrated distributed collaborative M&S environment is established which is capable of supporting system-of-system and cross-functional area tradeoffs and assessments.

II. APPROACH

The intended operational use of the RDEC Federation is as a collaboration between centers of excellence for various engineering and materiel disciplines to enable coordinated experimentation and analysis between and among the respective subject matter experts and authoritative simulations. Therefore, the RDEC Federation must contain engineering and engagement level simulator platforms and simulations networked together across the RDA community. This includes the Aviation and Missile Command's (AMCOM) aviation and missile simulations and data collection tools; the Tank, Automotive, and Armament Command's (TACOM) ground vehicle and armament simulations; the Communications and Electronics Command's (CECOM) Command, Control, Communications, and Computer Intelligence (C4I) and sensor simulations; the Soldier, Biological, and Chemical Command's (SBCCOM) individual soldier system models; the ARL vulnerability/lethality assessment models, human engineering models, HLA utilities, and Dismounted Infantry Simulation; STRICOM simulation support technologies such as Synthetic Environment Data Representation and Interchange Specification (SEDRIS), Computer Generated Forces, and the HLA gateway.

The federation must also be able to link with other elements of the Objective Force Battlespace (OFB), including U. S. Army Training and Doctrine Command (TRADOC) Battle Labs and Joint Virtual Battlespace (JVB) facilities to provide the appropriate scenario and battlespace context to conduct valid mission equipment simulation and evaluation in support of SMART. The federation will tend to be used at the Unit of Action (Brigade and Below) level of force structure, representing forces at the entity level. Aggregation will only be used by partner federations to represent the larger Unit of Employment (Division and Corps) and Joint and coalition forces context.

The basic operational approach for the implementation and use of the AMC RDEC Federation is to employ a combination of local and distributed simulation techniques, using constructive, virtual, and live simulations and simulators as the components. This provides the capability to represent a wide range of military systems, mission equipment, scenarios, environments, and battlespace capabilities. The exact combination of M&S tools and techniques used within the federation will be determined by the technical requirements of a given experiment, and the product required by the customer. In some instances pertaining to Science and Technology (S&T) research and engineering and Project Manager (PM) support, the work can be conducted locally within one simulation complex. However, when high-fidelity, engineering models or hot benches comprising multiple systems and subsystems are required to provide valid representations of the mission battle space and test environment, these systems will be accessed from the appropriate laboratories and facilities via networked simulations.

This operational approach forces the coordinated conversion and evolution of previously disparate simulation architectures at separately funded and managed facilities throughout AMC. Most of the legacy tools at these facilities had some inherent interoperability through Distributed Interactive Simulation (DIS) standards, and were gradually beginning to migrate to HLA on their own. These independent migrations ran the risk of having a low degree of interoperability due to the flexibility that HLA enables and the lack of a single clear vision of an AMC-wide interoperable architecture. These legacy DIS and HLA simulations are the critical investments that become the key architectural components of the combined federation. Therefore, the RDEC Federation Object Model (FOM) takes advantage of gateways, bridges, standardized FOM's, and extensions to ensure reuse of legacy simulations during the transition to a more native architecture.

Another determining factor in the design of the federation architecture is the premise that the respective subject matter experts in materiel technologies should own and operate the representations of those technologies in the federated architecture. Previously, each organization maintained platform-level simulations of the overall battlefield systems with their respective subsystems modeled in higher fidelity, paying only minor attention in general to the representations of the subsystems of other technologies, assuring only nominal performance. This approach was analytically dangerous because it ignored interdependencies between subsystem technologies and could bias results. But farming out the responsibility for subsystem representations to the right organizations could only be accomplished by breaking apart platform-level representations to represent systems in a distributed fashion. This led to a server-based approach for simulation of the systems of interest, with platform-level simulation relegated to the role of filling out the battlefield with other blue representations and threat forces.

This server approach allows the gradual migration of several parameters, such as increased fidelity of representations of function, failure, repair, and vulnerability at the component level, and the methodical breakout of other platform-level blue and red systems to eventually play more realistic support element behaviors and threat responses. The distribution of subsystem representation ownership also becomes a major element of the Verification, Validation, and Accreditation (VV&A) process for the performance data in the federation. The definitive data, models, and simulations become explicitly used within the federation and it reduces the requirement for subject matter experts to review and approve representation data in other products. For example, Six Degree-of-Freedom (6-DOF) flight date from a high fidelity missile model flown explicitly in the simulation would supercede any standardized hit probability tables from other sources. Standardized data will still be required for threat system performance and platform-level representations, but the server approach allows graceful migration away from these table-lookup approaches.

The RDEC Federation architecture also clearly delineates interoperability and interactions of truth and perception data. Many of the federation elements interoperate through tactical methods to stimulate tactical C4I devices or manned displays. These perception-data devices passively monitor the truth-data sources and must filter and process the truth data appropriately before publishing that data to a tactical device or operator. This capability is critical to the ability of the federation to be used for C4I experimentation, not only to keep from biasing experimental results with tactical access to simulated truth data, but also to measure the goodness of tactical data as compared to truth.

These factors combine to define a real-time, man-in-the-loop, federation architecture that bridges DIS, HLA, and tactical networks in such a way that legacy simulations are reused, platform-level simulations are decomposed, subsystems are represented in higher fidelity, and

C4I interfaces remain uncontaminated. Because the architecture is distributed, the respective hardware, software, and personnel of all the federation facilities can be brought to each experiment to provide a computational multiplier for architecture performance. However, this capability comes at the cost of the complexity of conducting geographically distributed events.

III. ARCHITECTURE

A. Runtime Interfaces

The architectural backbone of the RDEC Federation is HLA. Parallel to that backbone is a DIS network and a tactical C4I network.

The tactical C4I network interfaces are compatible with the evolving Army Tactical Command and Control System (ATCCS) standards and versions, and will continue to stimulate the latest tactical C4I equipment. In addition, there are some custom C4I interfaces to Research and Development (R&D) devices used to explore future C4I concepts, as defined by CECOM.

The RDEC Federation DIS network currently operates in accordance to DIS Version 2.04. Some non-standard Protocol Data Unit (PDU) traffic is also allowed on a case-by-case basis to allow DIS simulations to call and receive server information.

The DIS traffic is connected to the HLA backbone through a HLA gateway. The current gateway in use is MAK version 3.4, which is compatible with Realtime Platform Reference (RPR) Federation Object Model (FOM) 1.0 and is designed to ignore extension data to that FOM without dysfunction.

In addition to the primary FOM, the federation supports the use of multiple FOMs with bridges. Currently a one-way bridge is in use to link the RPR-based primary FOM with the Paint-The-Night (PTN) FOM. The PTN FOM consists of interactions allowing distributed control of sensor views from controls and switches in remote locations. The PTN architecture also uses Experimental Design Release (XDR), which is not supported by the primary architecture, and this bridged approach allows the two to interoperate.

The RDEC Federation backbone currently is running with HLA Run-Time Infrastructure (RTI) 1.3 Next Generation (NG). The primary RDEC FOM is a superset of the RPR FOM version 1.0, with extensions to allow exchange of server data and target acquisition data. The federation is following the GRIM guidelines for enumerations and implementation of RPR where possible. The servers currently supported are:

Missile Server
Munitions Server
APS Server
Mobility Server
Vulnerability Server.

Specific interfaces for these servers are under development, and not all simulations in the federation currently act as clients to these servers.

During the migration from DIS to HLA, servers may be accessed in various ways depending on where the respective clients reside on the network. Some servers will have dual DIS and HLA interfaces in a single process while others may be instantiated multiple times with custom interfaces. Some may utilize non-standard DIS PDU's or might even be incorporated internally in simulations that cannot subscribe to the server information.

Use of non-realtime simulations and federates is under consideration but is not part of the RDEC Federation architecture at this time. Joint Modeling and Simulation Systems (JMASS) is one possible non-realtime architecture that could support RDEC Federation integration and execution, and could provide engineering performance data for realtime use. Other non-realtime, high fidelity simulations are of interest to be incorporated in the federation, but interfaces are not yet defined.

The RDEC Federation uses the Defense Research and Engineering Network (DREN) to provide connectivity between facilities for integration and experimentation.

B. Synthetic Natural Environments

The RDEC Federation uses textured polygonal representations for visualization of terrain, features, and entities on the battlefield, and uses corresponding constructive versions of these same correlated terrain databases. Visual and infrared textures are used. Open Flight is the standard visualization format used in the federation, and is compatible with SEDRIS standards. For constructive simulations, Compact Terrain Data Base (CTDB) formats are used and converted as needed. CTDB version 7 is currently in use. The PTN sub-federation requires a much higher resolution terrain than the other federates, which drives the federation requirements and limits the types of terrain that the federation can use when conducting high-resolution image generation. PTN uses Performer Fast Binary (PFB) format terrain, which the federation has successfully converted to Open Flight and CTDB formats, but the terrain databases require significant downsampling and editing to run efficiently on non-PTN platforms. Open Flight files are also compacted to XIG format for use in some of the other visualization federates.

The RDEC Federation has not implemented any dynamic weather, obscurant, or terrain effects into the distributed Synthetic Natural Environment (SNE) architecture, but plans to rely on those developed for the JVB environmental and sensor servers when the federations are combined. Some of the RDEC Federation federates do represent dynamic environmental effects internally to the model, but currently the effects are not propagated and shared across the federation.

C. Key Architectural Components

The complete list of federates that constitute the RDEC Federation will continue to evolve. For any particular experiment, not all federates will be needed or used. Some of the key components of the RDEC Federation are as follows:

1. Platform Level Simulations

a. OneSAF Test Bed (OTB)

OTB is the primary platform level simulation used in the federation, representing all the red platforms and many of the blue ground forces. Currently the federation uses OTB v 1.0 which is DIS compliant. However, once the OF version of OTB is released through JVB, the RDEC Federation will adopt it as a native HLA application.

b. Interactive Distributed Engineering Evaluation & Analysis Simulation (IDEEAS)

IDEEAS is a platform-based constructive simulation developed and managed by AMRDEC, used for high fidelity missile simulations, and for representation of a number of advanced concept systems. IDEEAS uses more pre-defined constructive behaviors than OTB, which allows it to compliment OTB functionality in representing the suite of combat forces. IDEEAS is DIS or HLA compliant, represents environmental effects internally, and publishes extension data for target acquisition data collection.

c. Interactive Tactical Environment Management System (ITEMS)

ITEMS is a commercial platform level simulation used by AMRDEC to represent rotary and fixed-wing air assets. ITEMS version 6 is DIS compliant, and a RPR-FOM based HLA version is under development.

2. Virtual Prototypes

a. VETRONICS Technology Testbed (VTT)

For FCS applications, the TACOM VTT Systems Integration Lab (SIL) is used as the generic crew station for the RDEC Federation. FCS evaluation scenarios and alternative system configurations can be programmed into the VTT, which provides the RDEC Federation members a testbed into which they can integrate their system and sub-system models via distributed simulation.

b. Robotics Controllers

The TACOM Robotics OCU, the AMRDEC Experimental Unmanned Ground Vehicle (XUGV) robotic recon simulation, and the CECOM IUGS control stations are incorporated into the VTT as needed to allow man-in-the-loop operation and monitoring of unmanned robotics systems.

3. Dismounted Soldiers

a. Manned

ARL provides DISim as an operator controlled representation of an individual dismounted soldier.

b. Weapons

ARDEC provides a simulation of the Objective Individual Crew-served Weapon (OICW).

c. Operability

SBCCOM plans to incorporate the Integrated Unit Simulation System (IUSS) within the next year. The IUSS is a C++ PC platform-based architecture providing a comprehensive integrated analysis environment for the evaluation of dismounted warriors and their systems. The IUSS supports decision-makers by evaluating the combat effectiveness of current and projected equipment through a simulation of individual combatant and small unit combat operations in a simulated battlefield environment by measuring soldier/small unit operability in terms of survivability, mobility, sustainability and Command, Control, Communications and Computer Intelligence, Surveillance, and Reconnaissance (C4ISR).

4. C4ISR Simulations

a. Communications

The RDEC Federation includes Communications-Electronics research, Development, and Engineering (CERDEC's) Tactical Internet Model and Next Generation Performance Model (NGPM) to provide noise and message dropouts to simulate realistic digital communications and the appropriate degradation of GPS and SA performance.

b. Command and Control

The Commander's Interactive Display (CID) is a CERDEC research testbed for future command and control functions and displays. The CID displays tactical information fused from simulated sensor and reconnaissance sources to provide the warfighter-in-the-loop with advanced situational awareness, and provides decision support tools to support execution of commands in coordination with Battle Planning & Visualization tools. CERDEC also provides Force XXI Battle Command, Brigade, and Below (FBCB2) stimulation tools.

c. Fire Support

ARDEC provides a Future Fires Decision Support System (F2DSS) which receives tactical target report messages and calls for fire, provides decision support to a man-in-the-loop operator, and sends out the appropriate simulation network calls to missile and munitions servers. This system enables experimentation with future fire support capabilities while maintaining simulation interfaces to shooting systems. F2DSS is currently DIS compatible and is under conversion to HLA.

d. Sensor Suites

PTN is a CERDEC high fidelity target acquisition simulation which can drive remote displays in response to remote controls, allowing it to provide sensor views to virtual prototypes such as VTT. PTN visuals can be associated with any entity and sensor position and state, in order to augment client views with high resolution graphics. Weather and countermeasures servers are also incorporated into the PTN suite. CERDEC also has system and sensor representations for unmanned ground sensors, Unmanned Aerial Vehicles (UAVs), and Radio Frequency (RF) devices.

5. Servers

a. Vulnerability Server

ARL is developing a vulnerability/lethality server using an evolutionary approach. The initial version of the server was a monitor, tracking damage state changes on the federation. The server is currently being modified to publish traditional damage state changes based on centralized lookup tables for key systems. In the next step of evolution, server tables will be modified to represent unconventional damage categories for the full compliment of systems represented in the experiment. Ultimately, as subsystem-level simulation representations migrate towards component representation, and as computation processing increases, the vulnerability server is intended to provide component level and fault-tree damage states to client simulations in real-time.

b. Mobility Server

Tank, Automotive, and Armaments Research, Development, and Engineering Center (TARDEC) is developing a mobility server to determine trafficability and vehicle speeds over encoded portions of terrain. The server currently only uses the VTT as client, but the algorithms and route encoding will be extended to provide mobility information across the network.

c. Missile Server

AMRDEC has developed the missile server as an outgrowth of the IDEEAS simulation. The missile server receives fire requests from tactical or simulated entities and instantiates missiles in flight using high-fidelity kinematics and seeker models, and detonates missile warheads in accordance with accurate fusing. The missile server is currently limited in the types of missiles it can fire, with ballistic and fire-and-forget the most straightforward to simulate, but development is underway to populate the missile server with the entire compliment of missiles represented in the IDEEAS model. Interfaces are evolving from DIS to native HLA, and command-guidance update interactions with fire control systems are still under development.

d. Munitions Server

ARDEC is developing the munitions server in parallel to the AMRDEC missile server development, as a sister product. The initial focus of the munitions server is the Multi-Purpose Extended Range Munition, but a full compliment of munition representations is under development.

e. Active Protection System (APS) Server

AMRDEC has developed the APS server which is designed to provide a "success/fail" message to client machines when they are engaged by direct fire, so that the client can choose whether or not to invoke vulnerability tables. The APS server simulates the last few seconds of flight of enemy munitions and models the APS sensor and interceptor flight to high fidelity. The server currently uses a socket interface to the VTT, but is under modification to implement a native HLA interface so that multiple clients can be served across the network.

6. Tools

a. Data Collection & Analysis Tool (DCAT)

DCAT is an AMRDEC developed HLA and DIS compliant passive data collection tool providing real-time and post-process battlefield performance data based on user-defined on-the-fly measures of effectiveness. DCAT currently collects against any RPR FOM data and is under modification to collect target acquisition and server extension data.

b. HLA Simulation Experiment Monitor (HLA SEM)

ARL developed HLA SEM to sets of HLA attributes, and to display them in real-time to support analysis and experimental control.

IV. DATA AND RESULTS

RDEC Federation experiments can produce traditional digital DIS datalogs for playback and After Action Report (AAR), DCAT logs for post-analysis, individual analysis output files from various of the federates, and other documentary information such as computer video, over-the-shoulder camera data, human data collection, and audio logs from facility administration and tactical voice channels. From these digital data sets, timelines and battlefield performance can be derived for a number of different measures of effectiveness. As new experiments are defined, the analytical objectives of the experiment are compared to the current data collection capabilities, and new data collection requirements are derived. Other products for reuse in other experiments include terrain databases, scenario files, performance data sets, and advanced concept representations.

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